Space Weather Technical Forecast

Issued on Saturday, 29 July 2023 at 13:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: S2/Moderate Radiation Storm only gradually easing. R1-R2 Blackouts likely throughout. G1-G2 Minor/Moderate storms possible day 4 (01 Aug) with CME arrival.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with one M-flare peaking M4.1 at 28/1558 UTC from over the northwest limb, likely AR3364. The most active region of the eleven on the disc was AR3390, developing in the southeast, with a recent C9.2 flare. This region remains hard to assess due to its location. AR3380 is dominated by a mature trailer spot, but with a proliferation of smaller spots to its north. AR3386 has seen some small growth beyond its main leader, with smaller intermediate and trailer spots but maintains a fairly simple magnetic field. Activity from just over the northeast limb also suggests a further region is due to rotate onto the visible disc. The other regions remain smaller and simple, with no significant growth.

One Earth-directed CME was observed, with a partial halo observed on coronagraph imagery from the large filament eruption starting 28/2021 UTC in the northeast disc. No other Earth-directed CMEs have been observed.

Solar Wind / Geomagnetic Activity: Slow wind condition observed with solar wind speeds, as observed by DSCOVR at L1, around 370-410 km/s. Density was below average. Total interplanetary magnetic field (IMF), Bt, was mainly weak, at 5-7nT with the north-south component, Bz, having spells of weakly positive and negative orientation between -6nT and +7nT. Phi angle was predominantly positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux rose above S1/Minor Storm at 28/2350 UTC, and reached S2/Moderate Storm levels by 29/0530 UTC. This was in response to the far-side eruption on 28 Jul. This peaked at 154 pfu at 29/0920 UTC, then persisted at S2 (above 100 pfu) until the end of the period. GOES16 high energy (greater than 2MeV) electron flux ranged between moderate and background levels. 24-hour integrated fluence was 2.76e7 integrated pfu at 29/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Mainly Moderate activity is expected to continue with further M-class flares likely.

Solar Wind / Geomagnetic Activity: There is one Earth-directed CME from the large filament starting from 28/2021 UTC from the northeast disc. This is expected to arrive 01/1000 UTC +/- 9 hours. Otherwise mainly slow-wind conditions are expected with no significant enhancements indicated through the period. Mainly Quiet geomagnetic activity expected, with a chance of isolated Unsettled intervals. Activity likely increasing day 4 (01 Aug) to Active to G1 Minor Storm with the CME arrival, and a chance of G2 Moderate storm intervals.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to gradually, but erratically ease through the period, but likely remaining above the S1 threshold until the arrival of the expected CME on day 4 (01 Aug). The high energy electron flux

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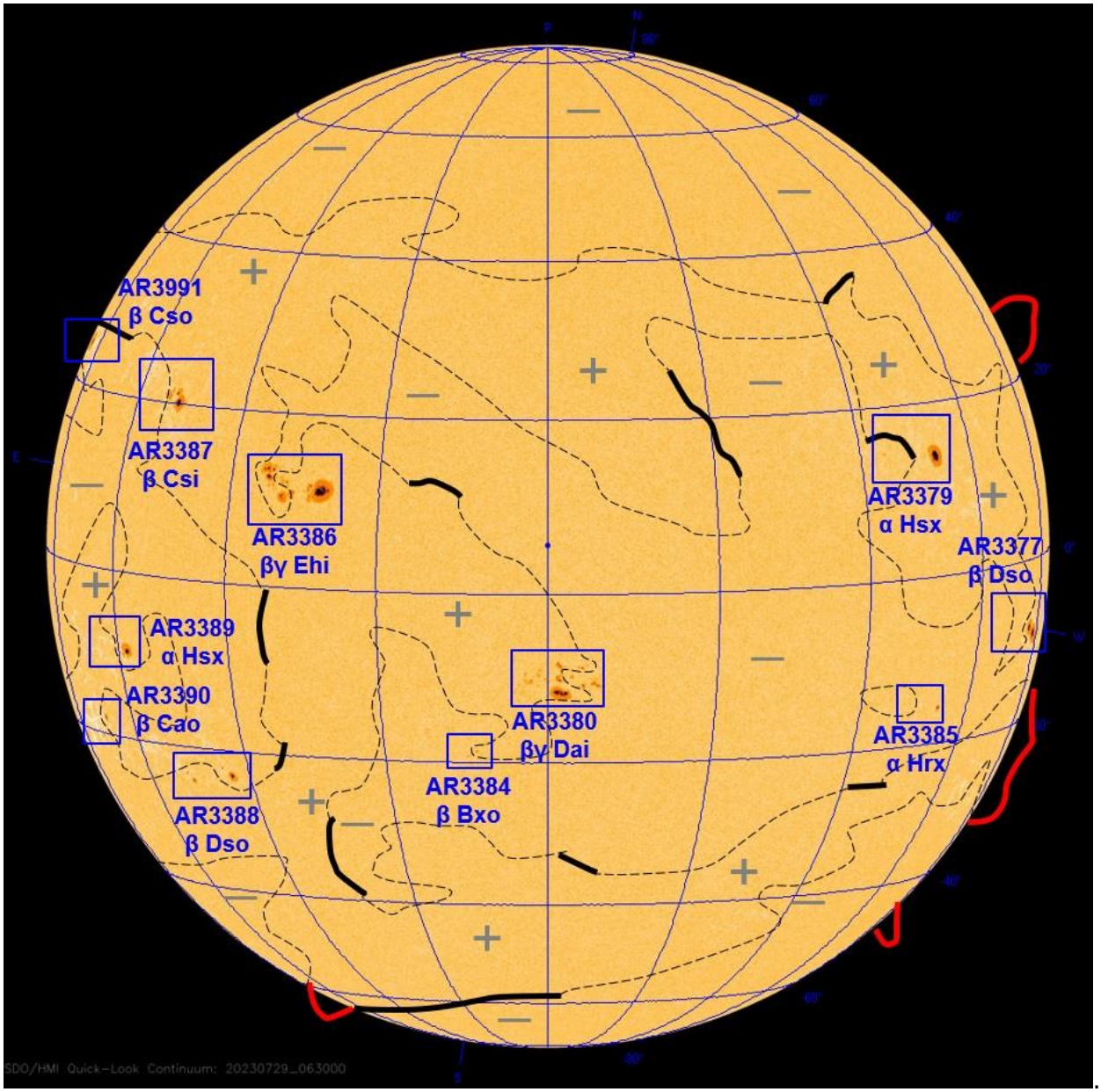
(greater than 10 MeV) is expected to continue at Background to Moderate levels with the associated fluence remaining below the Active threshold (1e8 total pfu).

Figure 1. Solar Analysis Valid 29/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A large filament lift was observed from the northeast disc, starting from 28/2021 UTC, but taking a couple of hours to completely lift. This produced a partial halo CME that has been assessed as Earth-directed, with a likely arrival time of 01/1000 UTC +/- 9 hours. No other Earth-directed CMEs feature.

Solar winds are currently at or near background with no other significant enhancements expected through the period. Mainly Quiet geomagnetic activity is expected, with a chance of isolated Unsettled intervals. Activity likely increasing day 4 (01 Aug) to Active to G1 Minor Storm with the CME arrival, and a chance of G2 Moderate storm intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	1	60
Strong	G3	No	1	1	1	10
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
29/0550	Partial Halo	Filament	NE	505 km/s	01/1000 +/- 9hrs	Limited shock expected Moderate confidence.

Figure 2a: SDO aia 304 and SOHO C3 showing faint halo

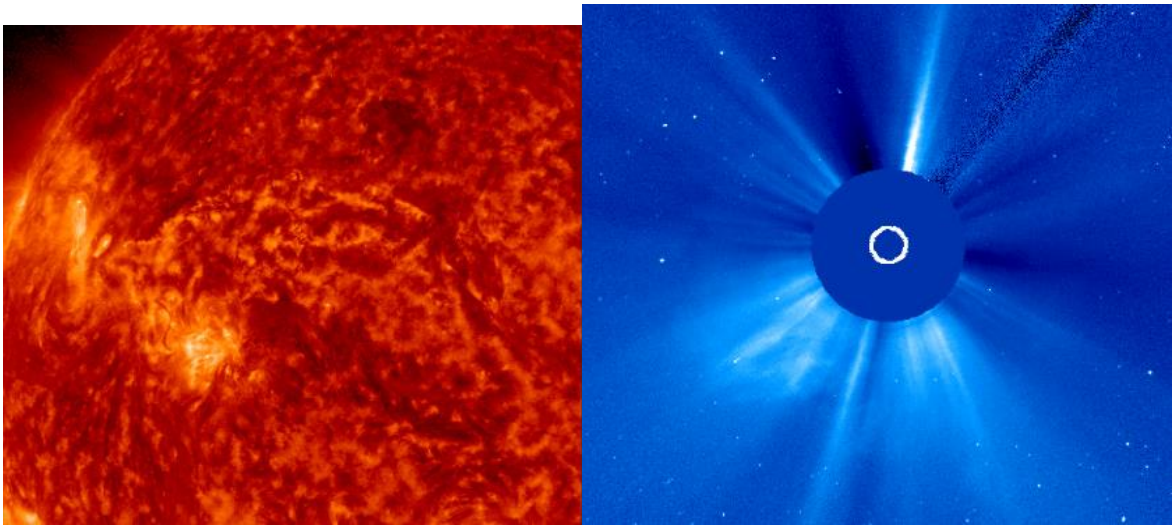

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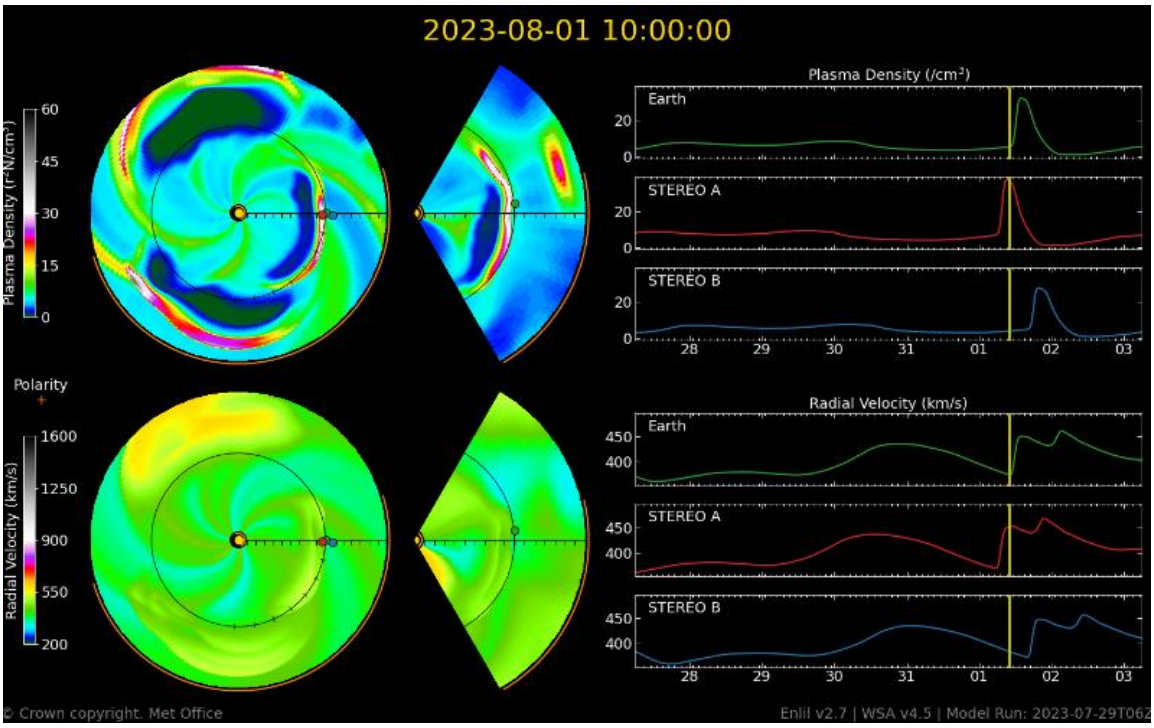
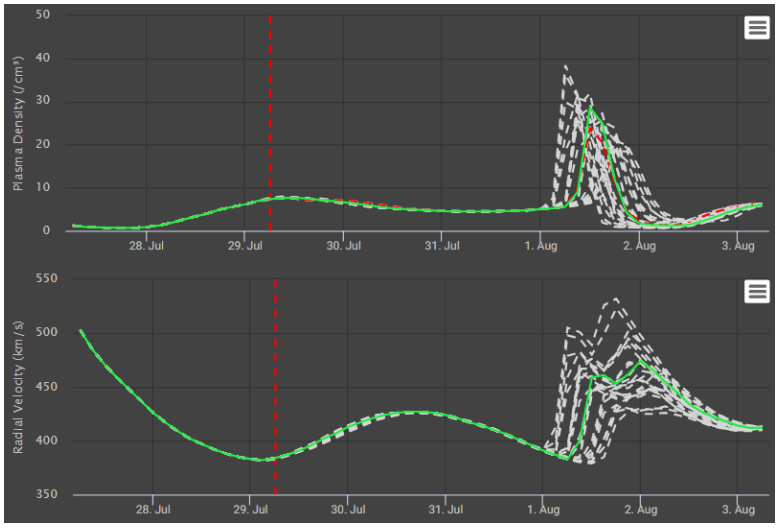
Figure 2b: Enlil and ensemble showing CME arrival





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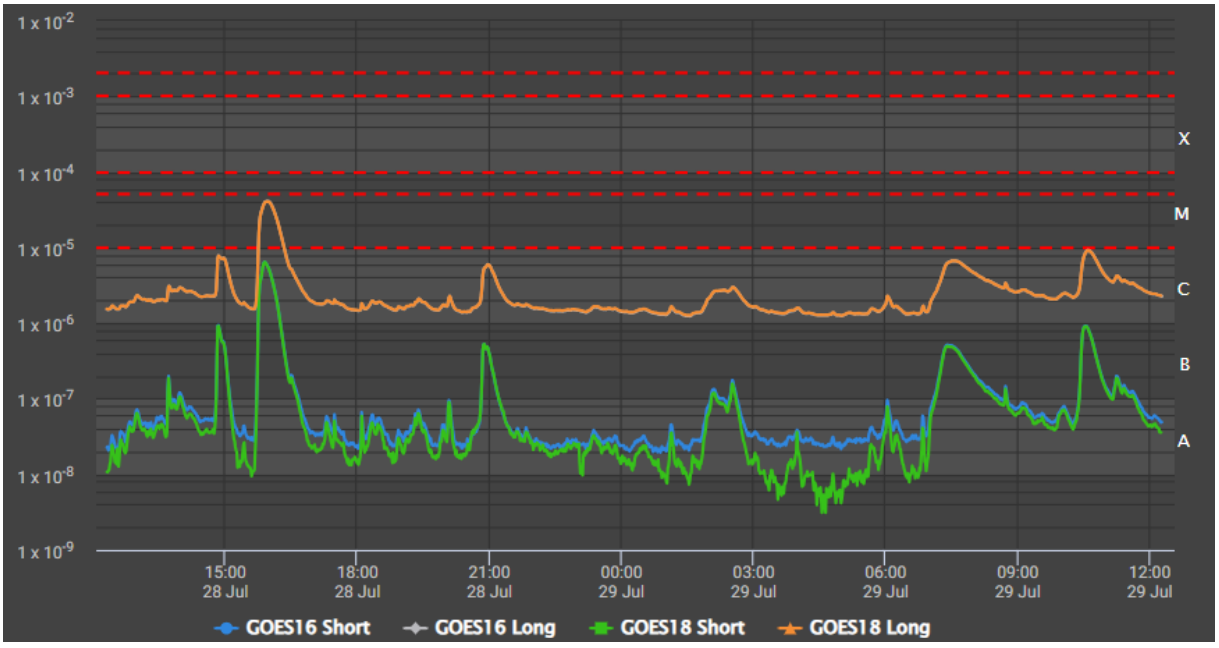
Radio Blackouts - X-Ray Flares:

Activity has been Moderate, however despite the eleven regions on the visible disc the only M-flare observed was likely from AR3376, from over the northwest limb. This peaked M4.1 at 28/1558 UTC

The majority of the regions on the disc are small and simple with little sign of development. The main exceptions are AR3380 in the south-centre disc and AR3386 in the northeast. AR3380 is dominated by a mature trailer spot, but with a proliferation of smaller spots to its north. It magnetic structure has the negative polarity spots slightly enveloped by the positive ones, leading to some subtle complexity. AR3386 has seen some small growth beyond its main leader, with smaller intermediate and trailer spots but maintains a fairly simple magnetic field. Activity from just over the northeast limb also suggests a further region is due to rotate onto the visible disc, with an occluded C6.7 on 29/0731 UTC flare and associated post-flare arcade loops evident on SDO aia-304.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	60	60
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16/18 X-ray Flux



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Solar Radiation Storms - (High Energy Protons):

The large far-side eruption, from the vicinity of AR3376 over the northwest limb, has resulted in an S2/Moderate Storm being observed by GOES-16. Peak flux has now plateaued and is likely to gradually and is forecast to erratically decline through the period unless further enhancements occur. Any further large flares from this region still have the potential to produced observable proton flux at Earth, although this risk is diminishing as it continues to move further onto the far-side.

Of the near-sided spots, the majority in the western hemisphere are smaller, simpler and less likely to produce significant flares and associated Earth-directed protons. The main near-sided spots that do carry a large flare risk are expected to move into a more Earth-connected position, and onto the western hemisphere, later in the period, however this risk will be counterbalanced with other regions, including what is left of AR3376 on the far-side, moving away. Overall there is only a slight chance for further enhancement to the flux, likely around 10%, with the main risk of greater than S1 levels due to the current ongoing event. The arrival of the CME, forecast on day 4 (1 August), may initially increase flux as it arrives, before flux levels decline once it has passed.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	95	75	60
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 >10MeV, >50MeV and >100 MeV Proton Flux

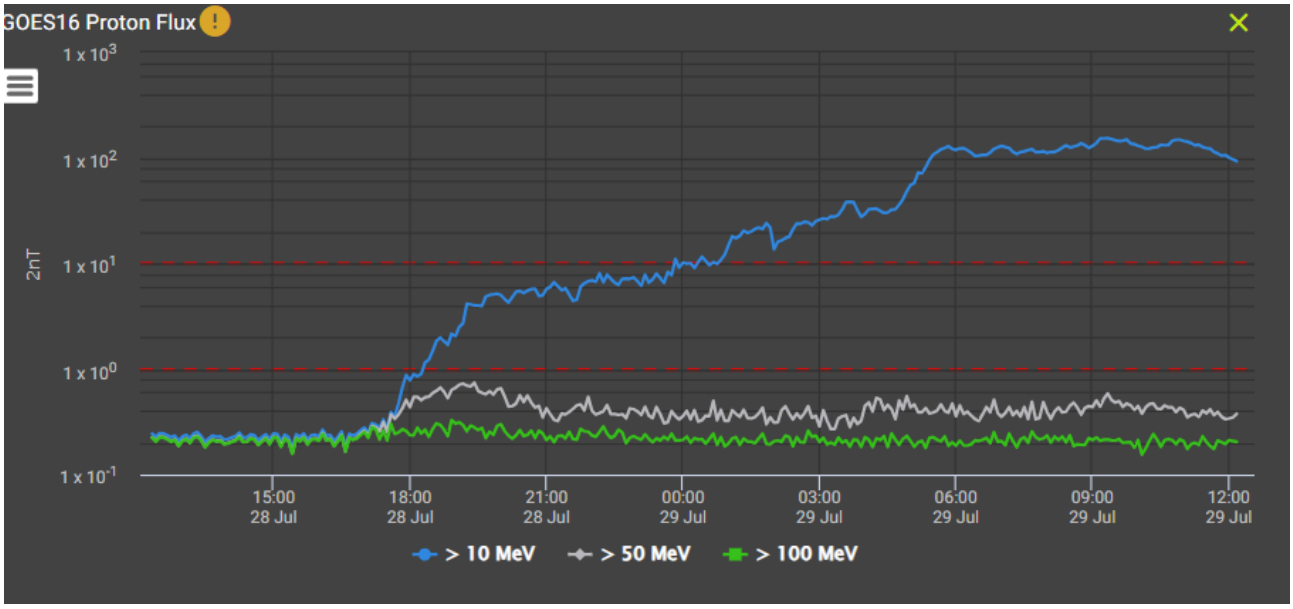

Figure 4b: SDO aia 304 (left) and SOHO C3 showing large eruption off NE.

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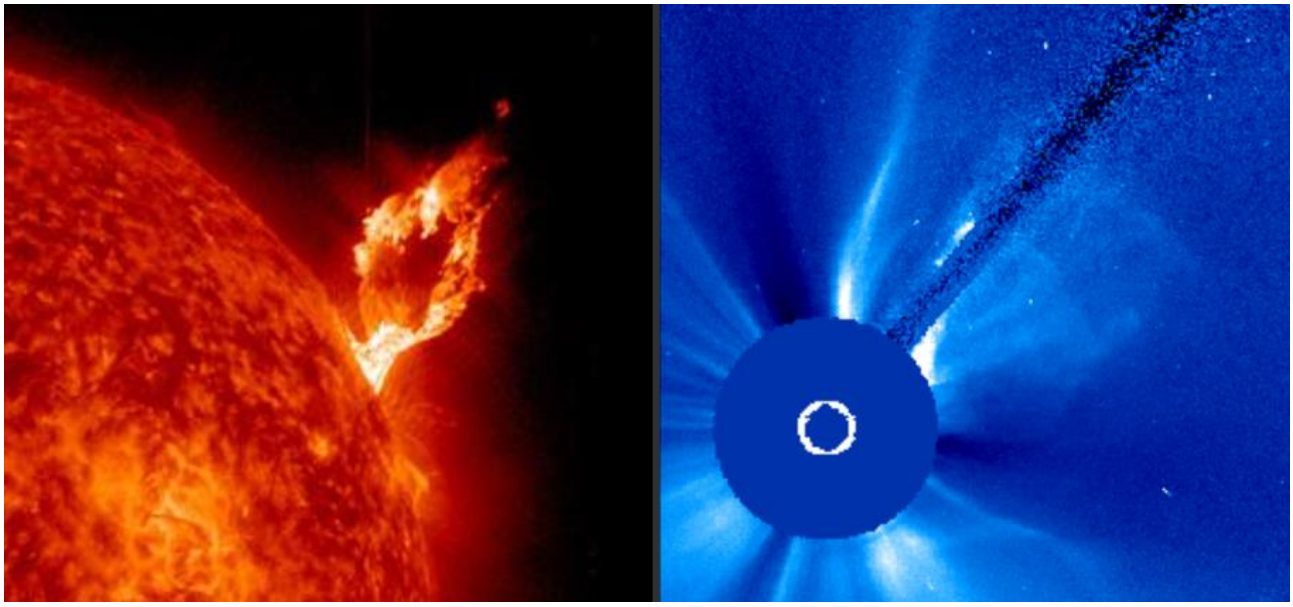

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES-16 is expected to continue exhibiting a diurnal variation between Background and Moderate values with no significant enhancements forecast. While not yet observed, some contamination to observations is possible however, due to the current ongoing S2 proton storm.

The associated 24 hour fluence is expected to remain below the Active (1e8 level), with REFM currently providing good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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